CONTRIBUTIONS

TO

MEDICAL SCIENCE.

BY

ALEXANDER OGSTON, M.D.,

ASSISTANT PROFESSOR OF MEDICAL JURISPRUDENCE IN THE UNIVERSITY OF ABERDEEN;
OPHTHALMIC SURGEON TO THE ABERDEEN ROYAL INFIRMARY;
JOINT OFFICER OF HEALTH FOR ABERDEEN;
AND LECTURER ON OPTHALMOSCOPY IN THE UNIVERSITY OF ABERDEEN.

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ALEXANDER OGSTON, M.D.,

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ON EXTRA-CAPSULAR FRACTURE OF THE FEMUR.

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In the study of fractures of any bone, the observation of the direction in which the fissures tend to run, especially when the direction and amount of the violence applied are, at the same time, taken into account, is of the greatest possible interest. There can be no doubt that the course of every fracture is determined by unalterable mechanical laws, and that if it were possible to find a series of cases where the same amount and direction of violence acted in a precisely similar way on bones presenting an identical conformation, the resulting fractures would be exactly similar in all the cases. Such a series of cases, however, is rarely met with, and the varying sorts of injury which present themselves are easily comprehensible when regard is had of the infinite variety of circumstances capable of modifying the result.

In some parts of the human body, however, the elimination of many of these modifying circumstances, such as muscular action, position, &c., and the proneness of the violence to be applied in much the same direction in many cases, lead to the

occurrence of injuries to a great extent similar to each other, and a knowledge of the general similarity of such injuries assists the surgeon in his diagnosis and treatment, as well as in the classification of his knowledge.

The upper part of the femur is a portion of the skeleton where the fractures can be arranged into a number of classes, and of all the injuries observable on the upper part of this bone, the extra-capsular fractures in the neighbourhood of the trochanter major are perhaps those in which the results obtained are most uniform, and correspond most with our application to the subject of mechanical laws. Extra-capsular fractures are more uniform in their appearance than intra-capsular fractures, and correspond, in this respect, with what is known of their causation, fractures within the capsular ligament being producible by the direct application of violence, as well as by shocks transmitted from the foot, knee, and so forth, while fractures external to this ligament are the result of the direct application of force to the trochanter major, and are usually traceable to a fall on this part over the side of the individual, so that the force is applied directly to the trochanter major, and in a line passing inwards, more or less along the neck of the bone, towards the centre of the pelvis. In other words, the force is applied in a similar manner to that which would be employed if, in an articulated skeleton, one were to hammer at the trochanter major with the intent to drive the head of the femur through the acetabulum. And so it sometimes happens that such a fall does drive the head of the femur through the bottom of the acetabulum and into the pelvis. When, however, the os innominatum does not yield, the whole force of the fall has to be borne by the neck of the thigh bone, a structure, which it will be remembered, though little compact in itself, is planted with its outer end in the trochanter major, a mass of tissue still less compact. The neck, too, receives the force in a favourable position, end on as it were, and, pillar-like, supports the strain without yielding. A glance at a femur shows the neck of the bone to be more like a cone than a pillar, the broad end of the cone, widest from above downwards, and narrowest from before backwards, being inserted into the trochanter major. The broad base of this cone, not yielding to the strain, also confers a power of resistance on the tissue immediately without it, and, similarly to what takes place when one forces a blunt body through a cork, carries a wedge of osseous tissue supported on its broad basis. This wedge of osseous tissue, whose shape corresponds with the end of the cervix femoris, being broad from above downwards and narrow from side to side, is similar in shape to the bottom of a boat, the keel running, as it were, in the broadest diameter of the base of the cervix, and in a direction from above down-

wards and a little backwards, a course corresponding with the greatest diameter of the neck of the thigh-bone. The head, neck, and wedge of tissue, thus refusing to give way to the strain, are driven through the substance of the trochanter major and upper part of the femur, and, a line of fracture having been already produced round the base of the cervix, corresponding more or less completely with the intertrochanteric lines, another fissure is caused in the bone by the projecting ridge at the apex of the wedge; and this line, separating the trochanter into a greater part broken entirely off, and a smaller remaining attached to the shaft of the femur, corresponds most accurately with the direction of the ridge surmounting the wedge, and consequently also with the greatest diameter of the cervix femoris. (It is curious to observe the accuracy with which this fissure, dividing the trochanter major, corresponds with the greatest diameter of the cervix,

Fig. 1.

Fig. 1.—Left femur. A, first fragment, head and neck. B, trochanteric fragment. C, shaft and part of trochanter. D, exostosis. E, line of fissure.

but the specimens in my possession, four in number, bear out the statement fully, and two other preparations, the only specimens of extra-capsular fracture in the University Pathological and Infirmary Museums in Aberdeen, are equally harmonious in this respect.)

It will be perceived that in extra-capsular fracture the bone is usually divided into three fragments, the first formed by the head and neck, the second by the greater part of the trochanter major, and the third by the shaft of the bone and a small portion of the trochanter major. The lines of fracture are, on the contrary, two in number, one corresponding very closely with the intertrochanteric lines and running sometimes through the centre of the trochanter minor, and the other, leaving the first fissure at the upper border of the neck of the femur, running thence downwards and a little backwards through the trochanter major, to rejoin the first fissure somewhere near the trochanter minor.— *(See Fig. 2.)*

The displacements occurring in such a fracture are very evident. The detached trochanter major is drawn upwards and backwards by the glutei medius and minimus, quadratus femoris, obturators, and pyriformis, and leaves between itself and the shaft a hollow, in which the fragment formed by the head and neck is placed. The shaft is also drawn upwards by the pelvic attachments of its muscles, and pushes upwards the outer end of the cervical fragment, which may besides be tilted up by the psoas and iliacus should the lesser trochanter be partially attached to this fragment, and not, as is usually the case, chiefly to the portion formed by the shaft. In this way the whole limb is shortened, the shortening being to a greater extent than in intra-capsular fracture, and the usual external rotation is effected by the usual agencies. The prominence of the trochanter major, too, appears less elevated than natural, for the two fragments being pulled away from each other, the wedge-shaped base of the cervical fragment lies immediately below the skin, and consequently the distance between the acetabulum and the skin is diminished. These appearances are well seen in the preparations of this fracture where union has occurred. The displacement upwards and backwards of the trochanteric fragment, the rotation of the lower fragment, shown by the position of the lesser trochanter, and the tilted-up end of the cervical fragment, where the neck, losing its usual oblique position, has become so horizontal as to be marked above by the articulating edge of the acetabulum, are all extremely prominent. This preparation where union has occurred has the following imperfect history : —" An old man, coming up a cellar stairs with a heavy weight on his back, lost his footing and fell backwards down the steps. When taken up, and attended to by my father, he presented the

usual signs of fracture of the neck of the right femur, with shortening, eversion, and crepitation. After six months' treatment he recovered and was able to walk about with a shortened

Fig. 2.

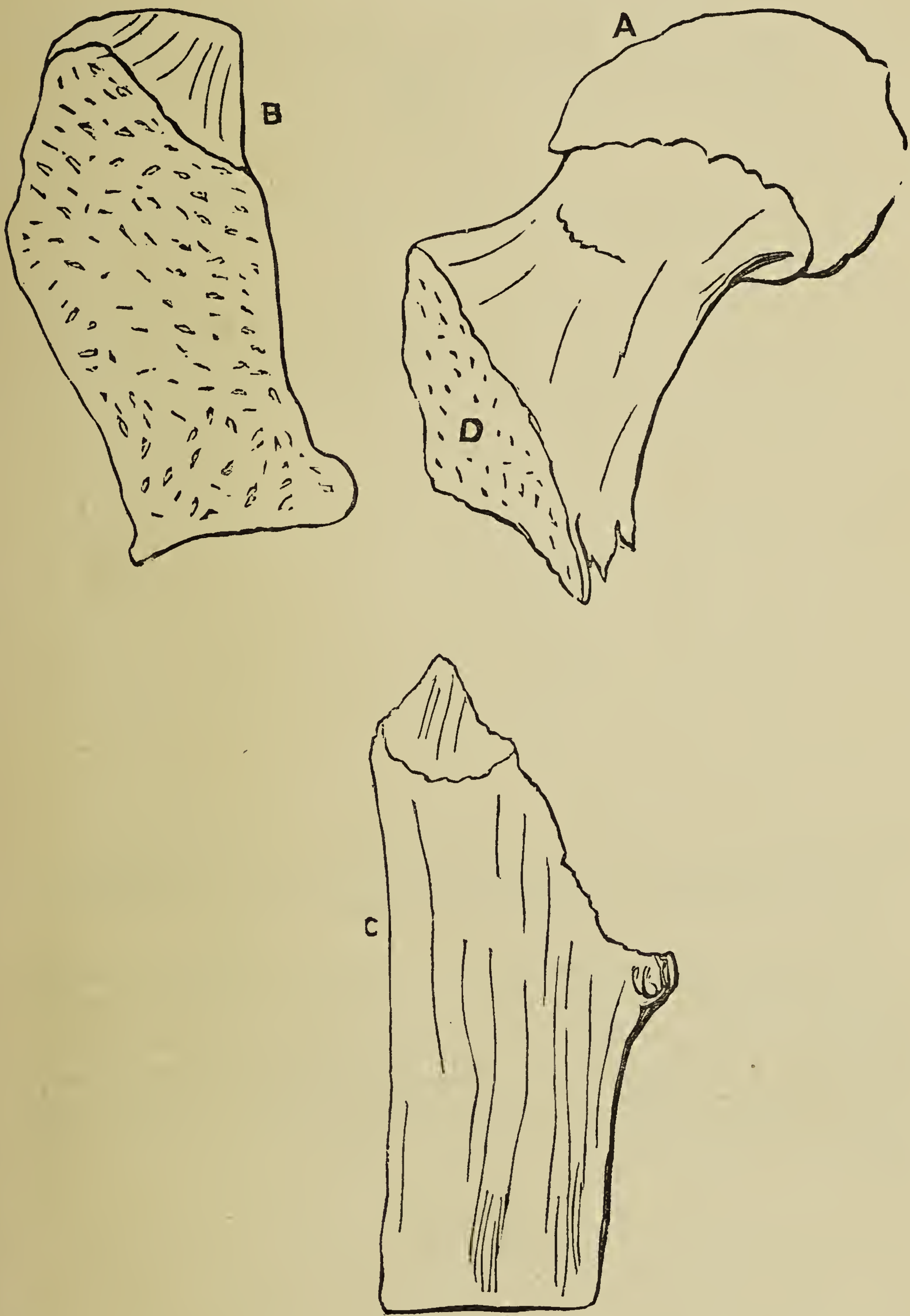

Fig. 2.—Right femur. A, first fragment, head and neck. B, second fragment, chiefly trochanteric. C, third fragment, shaft and trochanter. D, wedge of bone.

and everted limb. On his death, two years subsequently, the specimen was obtained."

Fig. 3.

Fig. 3.—Right femur, united extra-capsular fracture. A, cervical fragment. B, trochanter fragment. C, fragment formed by the shaft. D, new formation of bone. E, groove formed on cervix by acetabulum. F, trochanter minor.

The diagnosis of extra-capsular fracture is usually obscured by the amount of swelling and injury of the soft parts, for considerable violence is required to effect it; but the mode in which the injury was received, the ready crepitation, the large amount of shortening, and the altered relations of the three fragments, might in careful hands be sufficient to insure recognition of the injury.

ON THE FUNCTION OF THE SEMICIRCULAR CANALS OF THE INTERNAL EAR.

(Reprinted from the " British and Foreign Medico-Chirurgical Review " for July, 1869.*)*

THAT portion of the internal ear formed by the semicircular canals, although possessing a persistence of arrangement and a large number of marked peculiarities indicating it to be of no mean importance in the auditory system, has not as yet had any function assigned to it commensurate with its apparent position in the ecomony.

There are three semicircular canals in the human ear, and in the ears of the mammalia (Agassiz). " In birds the internal ear" is " constructed on the same plan as in mammals." " In reptiles the semicircular canals expand into ampullæ. In fishes the organ of hearing is reduced to a membranous sac, surmounted by semicircular canals, one to three in number. In osseous fishes" there exists " a simple vestibule or transparent sac, which receives the ampullæ of the arched canals, " and is separated by a partition from the auditory sac, which represents the cochlear portion of the internal ear. The semicircular canals are more or less developed in the different genera. " In the cyclostome fishes" there are " two wide and depressed semicircular canals, entering the vestibule by one common ampulla ;" while in the myxine there is a singled arched canal blended with the vestibule. Below this in the scale of life, semicircular canals are not found.

From this we see that these bodies exist in all the animals down to fishes, varying in number and appearance, but continuing after the cochlea and other parts of the internal ear have disappeared, and presenting the remarkable peculiarity of having their directions, where more than one of them exists, in planes at right angles to each other.

Such organs have indubitably some important function to perform, and although strong statements as to their use are not warrantable in the present state of our knowledge, there is a certain number of facts which appear to point to the purpose they serve with more or less distinctness. The application of experiment to the solution of the difficulty is unfortunately

attended with great uncertainty, and it is probable that pathological anatomy is the only means by which our knowledge of such a topic will be finally settled.

The persistence of this part of the essential organ of hearing (the internal ear), in classes of animals where the other part, or cochlea, no longer exists, seems to indicate that the functions of the two portions are separate and distinct, and the anatomy of the ear in the different genera from mammalia downwards, furnishes evidence of a similar character.

In mammalia the internal ear consists of three parts, viz. the semicircular canals—three in number, the vestibule, and the cochlea. The semicircular canals, placed behind the vestibule, are situated in densest part of the petrous portion of the temporal bone; they run in three different directions, and the plane of each canal is at right angles to the planes of the others. The superior canal is vertical in its position, and it runs in a plane at right angles in every direction to a line drawn from the forehead to the occiput; that is to say, one end of it runs upwards, then it turns in a direction toward the opposite ear or across the head, and finally it turns downwards to rejoin the tympanum. The posterior semicircular canal is also vertical in position, but it runs in a plane at right angles in every direction to a line drawn from ear to ear, its direction being at first upwards, then backwards, then downwards to the vestibule. The external canal is horizontal in position, running in a plane at right angles in every direction to the long axis of the body, being directed at first outwards toward the external ear, then backwards, and, finally, inwards again towards the centre of the head, to end in the vestibule. Each canal thus communicates with the vestibule by both of its ends, one end being small and of the calibre of the middle of the canal, the other end opening out into a flask-shaped swelling or ampulla as it approaches the vestibule. The external canal, that running in the horizontal plane, has no connection with either of the others; while the narrow ends of the superior and posterior canals meet and join the vestibule by one common opening. These arched canals contain membranous tubes in their interior, the tubes being about one-third of the diameter of the bony canals, and corresponding with them in shape and distribution, the membranous tubes dilating also at one end into ampullæ which nearly fill the cavities in which they lie, and on these ampullæ the branches of the auditory nerve are inserted, spread out, and terminate, not being continued along the tubes. The tubes float in an external fluid or perilymph, contain the endolymph in their interior, and communicate at both extremities with a sac lying in the vestibule, and which is denominated the utricle. Lying beside the utricle in the cavity of the vestibule is another sac called the saccule, communicating

with the cochlea, and having a cavity distinct from that of the utricle.

The cochlea, the other portion of the internal ear, consists of a spiral tube divided into two passages of equal size by a partition running along its whole length, so as to separate the two passages from each other, except at the top of the spiral where they communicate, while the other ends of the tubes are attached, one to the foramen rotundum, being closed off by a membranous partition from the middle ear, and the other to the saccule, foramen ovale, and stapes, being thus in connection with the chain of bones in the middle ear and with the drum of the ear. These spiral passages are filled with fluid.

It will be perceived that the cochlear portion of this apparatus alone possesses a direct and obvious connection with the middle and external ears, and correspondingly it is found that as the external ear disappears in animals the cochlea disappears also.

The distribution of the auditory nerve corresponds more or less with this anatomical arrangement, the cochlea being supplied by one separate branch, and the contents of the vestibule and semicircular canals by another.

From the whole of this arrangement it would appear as if the cochlea were the organ destined chiefly to receive impressions communicated from the external auditory meatus through the drum and chain of bones, and as if the contents of the vestibule and semicircular canals had a function quite separate and distinct from this. But before leaving the anatomy of the ear, it is necessary to call attention to the fact that the size of the arched canals varies in different individuals, and that their amplitude and development differ much in different animals, even of the same genus, being, for example, according to Agassiz and Gould, "broad and elevated in rapacious and passerine birds, and thick and depressed in the grallæ, gallinæ, and palmipedes." Doubtless, the varying development bears an intimate relationship to the habits and requirements of the animal, and a careful study of this relationship could not fail to throw much light upon the function of the part.

In considering the different properties which sound possesses with a view to arranging these properties into some sort of classification, we find that the ear is capable of distinguishing the varying intensity or loudness of sound, distance of sound, direction of sound, pitch or tone as in the different musical notes, and other peculiar qualities of sound as exemplified in the peculiarity of the violin notes, in contrast, say, with those of the harp. Of these, the first two, intensity and distance, are probably one and the same thing; the ear judging of the distance by the intensity; and this reduces the properties of sound as appreciated by the ear to four heads: 1st, Intensity;

2nd, Direction ; 3rd, Pitch ; and 4th, Minor peculiarities. Of these four, the last two have been chiefly studied ; and it is now generally accepted and believed that the pitch or tone depends on the number of vibrations taking place in a given time in the body producing the musical note, and that the minor peculiarities depend on secondary vibrations on the primary one. The function of perceiving these properties of sound is referred to the cochlear portion of the internal ear, the anatomical distribution of the nerves upon the central partition of this organ favouring such a view of its use. The first two heads, intensity and direction, have not received the same amount of attention, but it is believed that the intensity of sound is estimated by the tensor tympani muscle, which appreciates the strength of the vibrations of the drum of the ear, or by the nerves of the cochlea themselves, according to the force of the concussion they receive.

There remains then to be considered only the direction of sound, to which attention has not been sufficiently given.

If the attempt is made to ascertain what position in the appreciation of the direction of sound the external ear and external auditory passage occupy, it is found that no modification of the shape of the external ear has any sensible effect in preventing the just estimation of direction, that a common ear trumpet or ear speculum placed in one or both auditory passages, will not alter the exactness with which the locality of sound is perceived, although it must certainly alter the directions in which the waves of sound are conveyed into the meatus. Further, it will be found, and this is an experiment in the power of every one to verify, that closure of the external meatus on one side, and the consequent prevention of the entrance of any wave of sound, do not on that side of the skull modify the accuracy of the perception of the direction of a noise which is loud enough to be heard in spite of the closed meatus, and that the stoppage of entrance of waves of sound into either ear, by the firm closure of both the external passages, still permits all audible sounds to be unfailingly judged of as to direction. Since my attention was called to this subject, several opportunities of testing the correctness of this have occurred in individuals deaf from diseases of the middle ear, such as perforation or total destruction of the membrana tympani, with or without absence of the bones of the middle ear. In all of these persons the perception of the direction of sound showed itself to be entirely unimpaired, however severe the test to which it was subjected.

Facts like these lead to the inference that it is not from impressions communicated through the external and middle ear, or, at all events, not entirely from such, that direction of sound is estimated ; and if this be granted, it is but a step further to

admit that the cochlea is not the organ which takes cognisance of direction.

In proceeding further in this investigation, the question presents itself, how is direction of sound communicated, if not through the medium of the external and middle ear? and, fortunately, the reply has not far to be sought for. It is a well-known fact that in persons who are born totally deaf, the perception of the direction of sounds is not deficient too. It is so well known as to be used as a test to those shamming deafness, that an individual entirely deprived of the power of hearing, should the wall of his chamber be struck, or a bunch of keys let fall behind him, will forthwith turn in the direction of the sound to ascertain its cause. Such a person cannot hear the sound, he has lost the organ by which he might have perceived it, but he must still retain an organ capable of appreciating the direction of the sound, and to this organ the impression must be conveyed by vibration. It is not to the body and head merely that the vibration is communicated; such an agitation would probably be felt, but the direction whence it came could hardly be judged of, there must exist in addition an organ by which the direction can be estimated, and this organ, receiving the impression through the vibrations of the bones of the head, may perhaps be found in the semicircular canals.

There can be no doubt that the vibrations of sound *are* communicated to the ear through the medium of the bones of the skull, and communicated too with an intensity greater than when through the medium of the external auditory passage. In individuals in whom the external ear is closed by a tumour or plug of wax, or in whom the drum and bones of the middle ear being wanting, the fingers are placed in the external auditory meatus; should the internal ear be still intact, the sound of a tuning-fork with its handle placed on the vertex of the skull, is heard with a distinctness greatly exceeding that with which it is perceived when the handle of the fork is held close to the external ear. In individuals with perfect ears, the same thing holds true when the auditory passage is closed by the fingers or by a plug, and not only so, but when one ear alone is plugged, the sounds of the fork are more clearly audible in the closed than in the open ear, even should the fork be placed upon the temporal bone of the open side. This last fact is a most remarkable one, showing as it does that the vibrations conveyed by the bones of the skull are most distinctly perceived in the closed ear, even when the vibrations pass through the opposite open organ. Further examination of the power possessed by the bones of the skull in conveying vibration, shows that the more solid and the more directly connected with the auditory organ the part on which the fork is placed is, the more intense

are the sounds conveyed to the ear. With both ears stopped, a fork sounding in the middle line of the head is heard equally on both sides, and the more it is conveyed to one side, the more distinct are the impressions in that ear, sounds conveyed through the temporal bone being more distinct than when coming from most other directions. The upper jaw, for example, is a more integral part of the skull than the lower jaw, and sounds are better heard when the fork is placed on the teeth of the upper jaw, than when touching the teeth of the lower jaw, although false teeth in the upper jaw give a less clear impression than true teeth in the lower jaw. This is evidently owing to the ear being more solidly connected with the upper than with the lower maxilla.

These facts in connection with the greater clearness of sounds conveyed through the skull when the ears are closed than when they are open, have been attempted to be explained on the supposition that the plug, by its pressure, increases the density of the air contained in the middle ear, and so intensifies the vibration. But this explanation. indefinite as it is, is only partially if at all true, since a loose plug, incapable of exercising any influence on the air contained in the ear, such, for example, as a slight tuft of cotton wool gently laid into the external auditory passage, gives the same results as a tight plug. The true view of the case seems more likely to lie in the fact that the plug of wool or other substance cuts off the innumerable sounds continually passing into the external ear, and so permits the organ to form a more clear appreciation of the influences it may receive.

At the first glance this notion may seem much overdrawn, but the apparent exaggeration ceases when consideration is had of the immense multitude of sounds which, even in what we call silence, are constantly crowding in at our ears. Until attention is directed to it; the amount of sound about us, of which our senses take no note, is incredible; but very little observation will lead to the belief that we are seldom or never in the midst of silence. An approximate idea of the nature of our silence will be gained by those who, after prolonged residence in a quiet country district, have occasion to pass some time in a town. The din is most perceptible and annoying to such persons, although unheard or unheeded by the dwellers in the midst of it. And even in the country, the silence is only comparative. Most of us must have been struck with the feeling of quiet and stillness resting over such a place on a Sabbath morning, and doubtless such quiet was not mere fancy, but caused by the absence of the usual noises, wheels, human voices, and other sounds, which, though perhaps so faint as not to be recognisable as distinct sounds, were still conveyed to, and influenced, the

ear. A few reflections of this nature convince us of the truth of the terror which travellers attribute to the dead silence of the deserts, and explain why individuals who have lived long in an uninhabited district, catch and recognise as strange and important warnings, sounds so faint as to be inaudible to the ordinary ear.

It may not be permissible to adopt this effect of the plug in the ear as a complete explanation of the phenomenon, but it seems more rational than the previous notion about compressed air, and doubtless has at least some influence. At all events, the fact remains, that when one ear is lightly closed, the sound of a fork is more audible on that side, even when the handle is placed upon the temporal bone of the open side.

Before adverting to the experiments with the fork, it was asserted that sounds transmitted through the skull to the ear are more audible than those arriving through the external auditory meatus. In the preceding remarks, this has been proved only of closed ears, in which any channel might naturally be expected to conduct sounds more distinctly than the occluded passage. But in ears which are not closed, the transmission is better through the bones of the head than through the air contained in the meatus, and the reason why this is not generally perceived is, that sounds, in the usual course of things, are prevented from reaching the bones of the skull with great force, the force being intercepted and broken by the skin and tissues which everywhere cover them. By the only parts of the skull which are normally bare, that is, the teeth, sound is conducted far better than by the external ear, a fact easily demonstrable by comparing the sound of a tuning-fork placed with its handle close to the external ear, with that perceptible where its shaft is placed on the teeth. The greater intensity of sound in the latter situation is a fact familiar to every musician.

In the skin and soft parts themselves, common sounds excite vibrations quite capable of being perceived by the ordinary sensitive nerves, and therefore, when transmitted to the bones, sufficient to impress an organ specially adapted for receiving them. This is proved by the following case, selected from a small series of such observations. A gentleman suffering from chronic inflammation of the iris, from total adhesion of the pupil to the lens behind, volunteered the remark, that the circum-orbital pain, affecting principally the branches of the trifacial nerve supplying the scalp (frontal and auriculo-temporal), was always aroused to a great extent, or recalled when temporarily absent, by the sound of his children's voices, and by my own voice, however quietly our remarks were made. Some other sounds, as the rustling of a newspaper, produced the same effect.

There seems little reason to doubt that the surface of the scalp and bones of the head is a not unimportant part of the organ of hearing in man, and that it aids materially in collecting impressions of sound, especially impressions of direction. The instinctive attitude of a man listening for a faint and doubtful sound is a corroboration of this view, the position such a person assumes being with the head thrown a little forwards, and the hat or covering of the head removed. In animals it is found that among the higher classes, those species that lead the most active life, and are most dependent on the accuracy with which they can distinguish the direction of sounds, have the semicircular canals most largely developed, in confirmation of which the statement of Agassiz and Gould may again be quoted, that "the semicircular canals are broad and elevated in rapacious and passerine birds, and thick and depressed in the grallæ, gallinæ, and palmipedes."

In still lower orders of creation, for example, reptiles and fishes, where perception of direction of sound would seem to be of more importance than accuracy in discriminating quality, &c., the semicircular canals and utricle are found to persist, and the cochlea to have disappeared or become rudimentary. In many such animals, too, it is of importance to observe that along with these peculiarities in structure there coincides absence of the external ear, the skull and its coverings functionating as the only media for conducting impressions of sound.

The very shape and direction of the semicircular canals may be brought to confirm such a theory of their use. Their membranous tubes, filled with internal fluid (endolymph), and floating freely in external fluid (perilymph), are more suitable to taking up delicate sounds from the vibrating bones of the cranium than the cochlea, which contains only internal fluid. A vibration reaching those membranous tubes would affect markedly the fluid in their interior, and the vibration would naturally be conveyed by the wave of fluid along them to their larger extremities, where the ampullæ and utricle, the only parts provided with nervous filaments, are situated.

The position of the semicircular canals in the densest part of the temporal bone, and their invariable situation in planes at right angles to each other, have also been adverted to. The position of the external canal in the horizontal plane, and its more imperfect development, would agree with the fact that few impressions of direction require to be discriminated by the ear when they come from positions above or below the individual, and similarly, the two vertical canals, the superior and posterior, and their better development, would correspond with the necessity for frequent and accurate distinction of the direction of sound reaching the organ from all quarters more or less on a

level with the individual; the superior canal, that running across the head, taking cognisance chiefly of sounds coming from before or behind; the posterior, running from before backwards, perceiving those coming from either side. The union in mammalia of the narrow ends of these two latter canals, the superior and posterior, may be connected with their having, in their vertical position, so frequently to work together and assist each other. It appears likely that each canal would be most impressible to vibrations reaching it in a direction at right angles to its plane, striking it as it were on the flat, since such a vibration would act strongly on the whole length of the tube, while one coming from the direction of any part of the canal's plane, would act forcibly only on that portion of the circle placed at right angles to the direction whence it came.

From the considerations detailed above, it seems not improbable that the organ by which direction of sound is appreciated, consists of the utricle and semicircular canals, and that the bones of the skull and their coverings are important media for conducting sounds in such a manner that their direction may be known. By this it is, of course, not intended to be understood that the external ear and passage have no connection with such a function; they would, probably, also assist in conveying direction, and the semicircular canals and utricle may in addition be to a certain extent capable of appreciating quality of sound.

Such a view as has been advocated here, is, at all events, not completely untenable, while if confirmed by further observation, it would add one other important item to our knowledge of the physiology of the internal ear.

ON THE COMPARATIVE STRENGTH OF ARTERIES SECURED BY THE METHODS OF LIGATURE, ACUPRESSURE, AND TORSION.

(Reprinted from the Lancet for April 17, 1869, *and the "New York Medical Gazette.")*

In the contest still being carried on between the rival merits of ligature, acupressure, and torsion, experimentation on the dead body—a method which, it must be admitted, is capable of exercising at least some weight in the solution of the question—has not yet been brought so prominently forward as it deserves. Some points which the advocates of the different systems are seeking otherwise to demonstrate can be solved with great accuracy by means of experiment; and while the whole subject of the after-results of operations where each system has been employed is capable of being worked out only by clinical observation, their absolute and relative values as means of arresting hæmorrhage can by experiment be determined with very great certainty. Thus all it is requisite to know about an artery which has been submitted to the action of one of these hæmostatics, on purpose to judge of its power of controlling bleeding, is to be made aware of how much internal pressure a vessel so secured is able to resist. It is true that we cannot compare with absolute correctness the amount of resistance obtained with the force of the blood which in the living subject has to be resisted: before this could be indisputably accomplished, the amount of internal pressure exercised, under normal and abnormal conditions, by the blood, would have to be determined. Although this has not yet been done, something like a general idea of the force usually resisted by the wall of vessels can be formed; and by comparing this with the resistance of the three forms of hæmostatics, and these again with each other, a fair appreciation of their absolute and relative values can be arrived at.

The other conditions necessary for accurate experimentation are certainly present. A ligature can be applied as perfectly to a vessel removed from the body as to a living one; torsion can be as efficiently performed on the one as on the other; and some at least of the forms of acupressure are equally applicable under both circumstances.

In submitting the following results of a series of experiments as to the relative amount of internal pressure in inches of mercury required to overcome the artificial closure of divided vessels by ligature, acupressure, and torsion, an apology for their present incompleteness is necessary. In undertaking them, it was at first proposed to institute about a hundred several experiments, one-third of which was intended to refer to ligature, one-third to acupressure, and the remaining third to torsion. As yet, however, the results of only thirty-four such experiments have been collected, various causes having combined to prevent their being carried out to the full extent. The uniformity, however, of the results obtained leaves little room for doubt as to the correctness of the conclusions arrived at.

Among the circumstances which render them imperfect, besides their limited number, is our present ignorance as to the amount of internal pressure which the blood, in normal and abnormal conditions, exercises upon the walls of the human arteries, and as to the power of resistance of healthy and diseased vessels. The want of accurate knowledge on these points is very unfortunate ; for evidently we cannot be in a position to estimate by experiment the absolute or relative value of artificial means of closing wounded vessels, unless also aware of the amount of force with which the blood circulating in them tends usually to keep them patent. Thus, if the internal pressure on the walls of vessels is slight in degree, and if, even under unusual conditions, it is slight in comparison with the means we possess for resisting it, we are not justified in assuming that our frailest means of restraining arterial hæmorrhage may not be much more than sufficient to answer our purpose; since the force with which it is contending may be frailer still. It is by no means easy to fill up this important gap, for, to do this satisfactorily, it would be indispensable to have some experiments on arterial pressure which had been performed on the human subject. Of the existence of any such I am ignorant.

On purpose to have something, which, however deficient, would be better than mere guess-work to go by, a series of experiments were instituted to ascertain what weight laid upon the radial arteries at the wrist, where they are covered only by skin and aponeurosis, would be sufficient to obliterate their calibre. A small button was made to press upon the vessel, and its pressure was indicated upon a steel-yard; the amount of pressure at which the pulsations below ceased was carefully noted, and also the point at which they returned. The results of numerous experiments performed in this way did not always exactly correspond; but it was found that the artery was never controlled with less pressure than two pounds, and it never required more than a pressure of eight pounds to ensure the cessation of the pulsations.

So that the conclusion drawn was that a direct pressure of between two and eight pounds is what is usually necessary to obliterate an artery of the size of the radial at the wrist.

It would be difficult to say with what amount of internal pressure to the square inch this would correspond, the conditions of the experiment utterly forbidding any such calculation ; but, perhaps, it would not be too bold an assertion to state that, at the very least, two to eight pounds to the square inch may be assumed as the pressure of the blood. Assuming this, then, as the usual pressure of the blood, a reliable mode of securing wounded vessels is one which invariably permits the arteries subjected to its operation to resist an internal pressure of at least two to eight pounds to the square inch, or a column of four to sixteen inches of mercury.

Before submitting any of the methods to the test of the direct experiment, it was endeavoured to ascertain with the internal pressure of what number of inches of mercury the bursting point of healthy arteries corresponded. For this purpose it was desirable to obtain vessels which could be readily removed from the dead body without much close dissection, so as to allow of all their coats being invariably preserved intact, and which vessels should also have no branches. To this end selection was made of the common carotid arteries, which have very loose connexions and no branches, and which are removable without any trouble in the course of an ordinary post-mortem examination. For these, as well as for all the succeeding trials, the arteries were carefully removed, being cut through above their division into external and internal carotids, and at their proximal extremities as close as possible to the arteria innominata, or, on the left side to the arch of the aorta. They were selected from fresh bodies—always from those who had been less than forty-eight hours dead ; they were rejected if they showed any signs of disease or atheromatous degeneration, and were without delay submitted to experiment.

The dynamometer used for estimating the height of the column of mercury consisted of a glass tube, bent near its lower extremity at right angles, the short limb being drawn out into a bulbous nozzle, of such size that it slipped readily into the interior of the vessel. The vessels were, in all the experiments, secured to this nozzle by being bound to it with thick soft silk, wound round them at first lightly, and afterwards more firmly, so as to press the artery against the sides of the tube without injury to the internal and middle coats. The upper limb of the dynamometer was graduated in inches, and the one at first used was capable of containing a perpendicular column of fifty-four and a half inches of mercury. With this it was found impossible to burst the coats of a healthy carotid artery, and the

experiments were deferred until a longer tube, similar to the first, and capable of containing a perpendicular column of 114 inches of mercury, was procured. This second dynamometer had in its interior an iron wire slightly twisted into a spiral form, which broke the descent of the mercury poured in at the top, causing it to fall in a shower of minute drops on the column of the metal as it was ascending in the tube.

To the nozzle of this instrument one end of the vessel experimented on was secured as previously described, the free extremity, in the series of experiments undertaken to find the bursting point of arteries, being bound with similar silk, at first lightly, then more firmly wound round it, until the walls were pressed closely together, but without injury to the middle and internal coats, and until the end of the artery was enveloped in a ball of silk. The mercury was next poured gradually into the top of the tube, and its ascent watched on the graduated scale. Even with this height of column, however, it was found impossible to burst the walls of the arteries, as they resisted the pressure in every instance.

To avoid more waste of time in attempts to ascertain the bursting point, it was resolved to leave it undetermined, and to resume the attempts to find it, should it be necessary, in testing the resistance of vessels secured by ligature, acupressure, or torsion, to use a higher column than the 114 inches which the walls of healthy carotid arteries invariably resisted.

The next experiments were with torsion. One end of the artery being fixed on the instrument, the stem of the vessel was seized about two inches from the nozzle of the dynamometer, and being firmly fixed there by the hand or some properly protected instrument, the free extremity was next twisted off by a broad-pointed blunt forceps, like that used by Professor Syme in securing vessels. This twisting was continued till the end of the vessel came away of itself without pulling, to achieve which a considerable amount of twisting was required, and then the artery was left free, supported at the level of the lowest part of the perpendicular column, while the mercury was gradually added from the top, and the results recorded on the spot.

It was found that out of six vessels treated in this manner, no two gave exactly the same results. As soon as the mercury commenced to rise in the instrument, an untwisting motion commenced in the arteries, growing more and more evident as the column rose, until at length the jet of metal burst forth from the twisted end in a full stream, preceded by little or no oozing. In fact, it was plain that a small pressure indeed, if kept up, would in time have completely unclosed the artery, and that had the mercury not been quickly added, the pressure sustained would have been lower than was recorded. Out

of six experiments, one artery burst at 27 inches, one at 26 inches, one at 14 inches, one at 7 inches, one at 3 inches, and the other at 1·5 inch, giving an average of 13 inches of mercury as the resistance of a vessel secured by torsion. It will be perceived from these experiments that the average pressure sufficient to unclose the vessels—viz., 13 inches of mercury, or 6·5 pounds to the square inch, showed a resistance not equal to the 16 inches or 8 pounds assumed to be requisite, and that one of the vessels burst at 1·5 and another at 3 inches, a good deal lower than the extreme minimum of 4 inches. It would appear likely from this that vessels secured by torsion are very liable to secondary hæmorrhage, especially when the heart, recovering from the immediate shock of an operation, begins to beat more firmly, and to increase the arterial tension. Notwithstanding its advantages in leaving no foreign body in wounds, torsion seems as if it would be a dangerous hæmostatic. It is, however, open to experience to show the contrary.

In the vessels which had been subjected to torsion, the end removed, as well as the end left, was afterwards slit up, and carefully examined. It was found, as has been shown by others, that the calibre was closed by the intermixed ends of the fibres of the external coat, forming a thimble-shaped termination enclosing the ragged ends of the middle and internal coats, which were irregularly folded back for the space of a quarter of an inch or so into the bore of the artery.

The next experiments were with acupressed vessels. The method of acupressure used was always the fourth method of Pirrie and Keith, where, the needle being passed behind the artery, a loop of wire is placed over its point, the two ends brought back over the vessel on the other side from the needle, and secured by being twisted round the eye-end of the needle. The other methods are inapplicable to experiments undertaken on vessels removed from the body; and this fourth method, besides, is described by Pirrie as being "no doubt the most secure."

In the very first trials, it was found that when the arteries were acupressed with only sufficient firmness to bring their opposite walls into contact without cutting through the internal and middle coats, oozing from the secured ends occurred as soon as the perpendicular column of mercury began to rise and before it had attained an elevation of a few inches; so that in all the experiments subsequently performed (and the results of these alone are preserved) the wire was pulled so tight that the inner two coats were felt to give way—a fact always verified by the subsequent examination.

Out of twenty-one such trials the mercury was found to commence free oozing, or even to escape in strong jets, at 38, 41,

40, $43\frac{1}{2}$, 28, 6, 16, 53, 16, 37, 40, $29\frac{1}{2}$, $18\frac{1}{2}$, $4\frac{1}{2}$, 8, 6, 6, 24, 7, $20\frac{1}{2}$, and 11 inches of mercurial pressure, or on an average at 23·5 inches. It is further noticeable that, of those twenty-one cases, nine gave way under 16 inches of pressure, the lowest being $4\frac{1}{2}$ inches, none giving way under the assumed extreme minimum of 4 inches. Thus, if acupressure can be fairly judged from such experiments, it would seem a more reliable method of hæmostatics than torsion, but still not an absolutely certain means. At the same time, it is freely admitted that the observation of cases treated by acupressure in the Aberdeen Hospital would lead any impartial witness to believe it a most valuable plan in most cases, and where readily applicable. Its influence in producing primary union in wounds is undeniable; but in cases where primary adhesion could not be hoped for, its employment is uncalled for; and the superior results of ligatured vessels, when subjected to like experiments, show the superior safety of the old plan. One thing remains not quite clear, and that is, what becomes of the separated points of the internal and middle coats of the vessels, without which, unless a mass of tissue is included, acupressure by the fourth method cannot be efficiently performed?

The results of experiments on ligatured vessels require no long exposition. The ligatures were carefully applied, so as to cut through the internal and middle coats; and the vessels were, as in the other cases, carefully examined subsequently. In seven cases the pressure resisted was as much as the dynamometer allowed: the vessels refused to burst with 114 inches of mercury in every case except one, and in this the vessel gave way at $85\frac{1}{2}$ inches of pressure, but not at the site of the ligature. A rent opened in its wall at a distance of one-third of an inch above the ligature; and when the vessel was removed and examined, an atheromatous patch, previously unobserved, was found at the seat of the rupture. In one other case, a vessel which had been a good deal strained in fixing it upon the instrument, allowed a few beads of mercury to sweat through its walls at 70 inches of pressure, but bore, notwithstanding this, the full pressure of 114 inches, the escape of mercury ceasing as the column rose above 70 inches. These results are far above those of acupressure or torsion, and answer fully to the ideal resistance demanded.

If any conclusions can be founded on the above remarks, they are—that ligature is still our securest means of arresting hæmorrhage from wounded vessels; that the use of acupressure should be confined to those cases where its advantages are of use, as in wounds that may heal by first intention; and that prudence would forbid the application of torsion to large vessels, but allow its employment in small vessels, where the thickness

and the capacity of contraction possessed by the muscular coat, as well as the amount of tissue included in the torsion forceps, favour its employment. It is possible that the use of Lister's antiseptic ligatures may combine the security of the ligature with the advantages of leaving no irritating body in the wound; but at present it seems as if it were the surgeon's wisdom to use the different means in the cases suitable for each, instead of aiming at the exclusive employment of any one method.

ABERDEEN, *March*, 1867.

TABLE OF CASES, WITH WEIGHTS OF THE BODIES AND LUNGS OF LIVE AND STILL-BORN CHILDREN.

(Reprinted from the "British and Foreign Medico-Chirurgical Review" for October, 1868.)

No.	Sex.	Live or still born.	Condition when examined.	Weight of body in grains.	Weight of lungs in grains.
1	Male.	Live birth.	Fresh.	58,625	940
2	"	"	"	53,812·5	1421
3	Female.	"	Decomposed.	31,500	420
4	Male.	Still birth.	Fresh.	33,410	494
5	Female.	"	"	15,968	488
6	"	Live birth.	"	44,515·6	568
7	Male.	"	Decomposed.	54,031·2	1200
8	"	Still birth.	Fresh.	14,054·7	300
9	Female.	"	Decomposed.	47,468	410
10	Male.	"	Fresh.	19,250	690
11	"	"	Decomposed.	45,937·5	640
12	"	Live birth.	Fresh.	54,250	1205
13	Female.	Still birth.	Decomposed.	8,750	200
14	"	Live birth.	Fresh.	45,718·7	730
15	"	"	Decomposed.	35,000	706
16	Male.	"	Fresh.	56,437·5	736
17	Female.	Still birth.	Decomposed.	45,062·5	640
18	Male.	"	Fresh.	20,125	540
19	Female.	Live birth.	"	56,617·5	859
20	"	Still birth.	"	31,937·5	589
21	Male.	"	"	13,125	120
22	"	"	"	57,750	1103
23	Female.	Live birth.	"	37,625	745
24	"	Still birth.	"	51,843·7	1315
25	"	"	"	15,968·7	507
26	"	Live birth.	"	37,625	726
27	"	"	Decomposed.	24,937·5	655
28	"	"	Fresh.	44,187·5	746
29	Male.	Live birth.	"	46,932·5	816
30	"	"	"	32,998·5	640
31	Female.	"	"	37,625	661·5
32	"	"	"	42,875	600
33	"	"	"	44,625	1008
34	"	Still birth.	Decomposed.	16,734·3	470
35	Male.	Live birth.	Fresh.	51,625	723
36	"	"	"	39,648·5	1220
37	Female.	"	Decomposed.	41,545	890
38	"	"	Fresh.	47,468·8	761
39	"	"	"	38,500	709
40	Male.	"	"	35,000	464
41	Female.	"	"	49,000	858
42	Male.	"	Decomposed.	49,546·7	660
43	Female.	"	Fresh.	48,125	856
44	"	"	"	47,507·5	774
45	"	"	"	43,750	643

No.	Sex.	Live or still born.	Condition when examined.	Weight of body in grains.	Weight of lungs in grains.
46	Female.	Live birth.	Fresh.	40,796·7	960
47	Male.	"	"	45,500	781
48	Female.	"	"	47,468·7	1057
49	Male.	"	Decomposed.	49,000	680
50	"	"	Fresh.	42,000	1127
51	Female.	"	"	31,500	990
52	"	"	"	32,812·5	810
53	"	"	"	57,750	1035
54	Male.	"	"	53,375	1046
55	"	Still birth.	"	15,750	488
56	Female.	Live birth.	"	42,000	692
57	"	"	"	46,593·7	865
58	"	"	"	43,750	690
59	Male.	"	"	56,000	920
60	Female.	"	"	56,000	1029
61	Male.	"	"	55,562·5	875

Out of a total of eighty-one cases, in which the question as to the live or still birth of a child had to be answered by the medical jurist to the law authorities from a post-mortem inspection of the bodies of the children, and which are recorded in the medico-legal reports of Professor Ogston, University of Aberdeen, there are sixty-one in which the particulars as to *the weight of the body and lungs* are given, as well as every other information necessary to be provided with in judging of the *value* of these weights as corroborative evidence in the question of live or still birth. More than corroborative they certainly cannot be, the condition of the lungs is in competent hands an unfailing means of answering this important question, and the variation in the weight of body and lungs, as well as of their relations to each other, are too great and too general to admit of such a claim.

The above sixty-one cases, drawn up in the form of a table, give us, however, some results which it may be well to remember in judging of such cases. They are given in the order in which they occurred in practice, with the exception of the first, which is drawn from the practice of a physician in a neighbouring county. In deciding as to live or still birth, the condition of the lungs was the evidence relied on. In the column relating to freshness or putridity, the condition of the body was not so much taken into account as the state of the lungs themselves, for it is well known that the lungs are not the organs of the body soonest affected by decomposition, and a commencing decay of the body does not at first effect the lungs at all. The weights of the bodies were taken in imperial pounds, ounces, and parts of ounces, which explains the decimals of grains so often occurring in this column. The lungs were weighed by apothecaries' weight, excepting Case 31, where imperial weight was used. In the above table the weights

have been reduced to grains for the sake of greater ease in comparison.

Out of the sixteen cases of still birth, eight are males and eight females. The aggregate weight of the lungs in the males is 4375 grains, of the bodies 219,402·2 grains, or a proportion of 1 : 50·103. In the females, lungs = 4628, and bodies 233,723·7 grains, or 1 : 50·502.

In the live births, where the lungs are fresh, a total of thirty-eight cases shows fourteen males, with the total weight of the lungs 12,914, and of the bodies 681,767 grains, or 1 : 52·792, and twenty-four females with the total weight of the lungs 19,390·5, and of the bodies 1,064,437·2 grains, or 1 : 54·847.

In live births, where the lungs were decomposed, out of seven cases three were males and four were females. The males have the total weight of the lungs 2540 grains, and of the bodies 143,577·9 grains, or 1 : 56·526 ; the females having the total weight of the lungs 2671, and of the bodies 132,982·5 grains, or 1 : 49·787.

Now, comparing these figures, we find the proportion of the weight of the lungs to that of the body to be, disregarding sex—

In still birth.	In decomposed live births.	In fresh live births.
1 : 50·302	1 : 53·156	1 : 53·819

And in all live births, disregarding the state of freshness or decomposition, 1 : 53·487.

This leads us to the result that, *although common sense indicates an increase of absolute weight in the lungs after inspiration, and consequently an increased ratio of weight to that of the body*, in the above table of cases the weight of the lungs to that of the body is greater in *still* than in *live* births—just the reverse of what might have been expected. Why this should be so is not to be explained, but the conclusion to which we are driven is, that in deciding between live and still birth the ratio of the weight of the lungs to that of the body is quite worthless.

Looking next at the *absolute* weight of the lungs, great differences present themselves. In one case of still birth the lungs weighed 1315 grains, and in one case of live birth they weighed only 420 grains. But in the general run of live births the weights of the lungs are greater than in the generality of still births ; and the averages bring this out in a pretty marked degree, for we have—

Average weight of still-born lungs		= 562·6
,, ,,	live-born decomposed lungs	= 744·4
,, ,,	,, fresh ,,	= 850·1
,, ,,	all live-born lungs	= 833·6

The average absolute weight of still-born lungs being thus about five-eighths of that of live-born lungs; whence we conclude that, although in any one given case the absolute weight of the lungs is inadequate to decide the question of live or still birth, still, as corroborative evidence, it is not without value, and may be allowed a certain amount of weight along with the other uncertain signs of live birth in deciding this often very important question.

CASE OF EXCISION OF THE CALCANEUM.

(Reprinted from the "British Medical Journal" for 8th May, 1869.)

M. L., aged 13, of a scrofulous habit of body, and subject to various manifestations of this tendency, suffered from an attack of chronic tympanitis, the cause of which was not apparent, during February, March, and April, 1867. From this she recovered, but came again under treatment in May 1867, for caries of the calcaneum, said to have already existed for a considerable time. There was a fistulous opening on the outer side of the heel, emitting a small amount of purulent discharge, and leading down to roughened bone, the roughened surface having an apparent breadth of three-fourths of an inch, and being circular and depressed. From the tenderness of the calcaneum on pressure, she could not put the heel to the ground, and consequently used crutches. Ten months later, no improvement appearing under tonic treatment and rest, and the discharge increasing in quantity, operative interference was decided on; and an incision was made across the discharging sinus, and parallel to the outer edge to the sole of the foot, the girl being under chloroform. This wound revealing the existence of a chronic ulcer of the calcaneum, with depressed bottom and hard surface, the incision was continued backwards to the centre of the tendo Achillis, and anteriorly to the middle of the cuboid bone, and was met by a second incision, running downwards from near the cuboid end of the first to more than half way across the sole of the foot in the situation of the instep. The incisions were deepened till the bone was exposed, and the dissection continued along its surfaces, until—the astragalo-calcanean and calcaneo-cuboid articulations being also divided—the calcaneum was entirely removed. No vessel required to be secured, and no tendons were cut, except the tendo Achillis at its insertion into the back part of the calcaneum.

Eight months after the operation (in October 1868), the wounds having entirely healed, she was able to walk with the aid of a high-heeled boot. When shown to the Aberdeen Medico-Chirurgical Society, in March 1869, the heel was half an inch shorter than on the opposite side, and she was able to walk almost any distance, and with a barely perceptible limp.

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